

Potential effects of riparian vegetation changes on functional organisation of macroinvertebrates in central Victorian streams

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Abstract

Exotic willows (*Salix* spp.) are widespread riparian tree species of rivers in temperate Australia and New Zealand. Despite being a Weed of National Significance, little is known about the novel habitats created by willows and the impact on aquatic biota of vegetation change following willow management programs. Reeds (*Phragmites australis*) and shrubs (*Leptospermum* spp. and *Callistemon* spp.) are common taxa in the riparian zone of Victorian streams and are considered suitable for planting along channels in revegetation programs following willow removal. Categorisation of macroinvertebrates into 'trophic' groups allows better understanding of the processes of energy flow, material cycle and stream ecosystem function. Macroinvertebrate functional feeding groups associated with willow, *Phragmites australis*, *Leptospermum/Callistemon* and bare bank habitats were examined in three central Victorian streams to gain insights to potential effects of willow removal on functional organisation of macroinvertebrates. There was a significant effect of habitat on macroinvertebrate functional feeding groups except collectors. Notable differences in functional feeding groups included a greater abundance of predators and grazers in *Phragmites* habitats and a greater abundance of shredders in willow habitats; however, these changes were variable during different seasons. It appears riparian vegetation change associated with willow management could bring about change of functional organisation of macroinvertebrates in these streams. This suggests that the vegetation changes can bring about changes in material cycle and energy flow within these streams. (*The Victorian Naturalist* 127 (2) 2010, 36-48)

Keywords: *Phragmites*, willow (*Salix* spp.), *Leptospermum*, Macroinvertebrates, Functional feeders

Introduction

Categorisation of macroinvertebrates into 'trophic' groups allows better understanding of the processes of energy flow, material cycling and stream ecosystem function (Cummins 1973). These groups include: (1) grazers: which are adapted to graze or scrape material (periphyton or attached algae and its associated microbiota) from mineral and organic substrates; (2) shredders: organisms that feed primarily on large pieces of decomposing vascular plant tissue (>1 mm diameter) along with the associated microflora and fauna; (3) gatherers or collectors: animals that feed primarily on fine particulate organic matter (<1 mm diameter) (FPOM) deposited in streams; (4) filterers: animals with specialised anatomical structures (e.g. setae, mouth brushes, fans etc.) or silk suspension (Wallace and Merritt 1980) and (5) predators: organisms that feed primarily on animal tissue by either engulfing their prey or piercing and sucking body contents.

The River Continuum Concept (RCC) proposed by Vannote *et al.* (1980) has led to a

number of generalisations about spatial and temporal patterns in the functional organisation of stream communities. Several studies in the Northern Hemisphere have shown that the life histories of many invertebrate species are closely linked to the autumnal leaf fall pattern of riparian vegetation (Petersen and Cummins 1974; McArthur *et al.* 1988) and suggest this pulse of energy benefits shredders in particular. Riparian vegetation also has a direct influence on primary production in streams, hence an indirect influence on secondary production through the effect of shading (Quinn *et al.* 1997). Many studies found that grazers are more responsive to an increase in primary production (Glova and Sagar 1994; Lester *et al.* 1994). These findings suggest that changes in riparian vegetation composition have a significant influence over the macroinvertebrate community composition and their functional organisation in streams.

Exotic willows have successfully colonised and become naturalised along many riverbanks

in temperate Australia (Ladson *et al.* 1997). It is estimated that willows have spread across approximately 30 000 km of the 68 000 km river frontage in Victoria (Ladson *et al.* 1997). Willows are considered a Weed of National Significance in Australia and willow management strategies recommend their removal as the preferred and generally only management option (National Weeds Strategy Executive Committee 2000). Revegetation is encouraged following removal. *Phragmites australis* is one of the common native reeds of open streams and wetlands worldwide (Sainty and Jacobs 1981). Invasion of *Phragmites* in open reaches with low riparian vegetation cover has been observed in many river catchments in Victoria (CALP 1997) and redistribution of *Phragmites* in rivers managed by irrigation has been observed in south-eastern Australia (Roberts 2000). In addition, *Phragmites* sometimes has been used during revegetation. The nature and availability of *Phragmites*, therefore, increases the likelihood that it will be a coloniser of banks following willow removal. Native shrubs such as *Leptospermum* spp. and *Callistemon* spp. are common in many temperate Australian streams and are a significant component in the riparian zone of streams where willows are removed. It can be expected that such changes in riparian vegetation can significantly influence the macroinvertebrate functional organisation in these streams; however, empirical evidence is scant.

In Australia, evergreen native vegetation has a continuous leaf fall through the year, usually with a peak around late summer (Campbell *et al.* 1992; Swain *et al.* 1993). This provides a continuous food source for macroinvertebrates, which presumably have adapted to this pattern of litter distribution. According to Vannote's prediction, shredders in Australian streams must occur at greatest densities during summer and autumn, just after the major litter fall. By contrast, introduced willows are deciduous, dropping all their leaves in autumn over a relatively short period of time. Their leaves break down faster than those of many native species (Pidgeon and Cairns 1981; Yeates 1994). It was suggested that invasion of exotic willows along many river catchments has led to changes in the community organisation of macroinvertebrates that were previously adapted to a continuous energy supply from native riparian tree species (ARMCANZ 2000). It can be expected that de-

ciduous willows contribute a pulse of leaf litter input to streams during autumn, which could contribute to the increase of shredder abundance during those seasons. Reeds can be expected to provide habitats for filter feeders and suspension feeders due to their retention characteristics (Weinstein and Balleto 1999; Rooth and Stevenson 2000). Predators are also an important component in the functional organisation of communities in streams. Evidence suggests that certain habitats, such as those with macrophytes, facilitate predator abundance in streams, more so than other habitats, e.g. those with little or no macrophytes (Tokeshi and Pinder 1985). Therefore, it is important to explore how vegetation transition processes facilitate predator abundance. *Leptospermum* and *Callistemon* are common shrubs along many Victorian streams and provide year-round leaf litter input to these streams; however, their contribution to functional feeding groups of macroinvertebrates is unknown. The aim of this study was to determine the likely change in macroinvertebrate functional feeding groups after willow removal in three Victorian creeks. This information then could be used to predict the consequences of willow removal on macroinvertebrate functional feeding groups.

Methods

Study sites

Three creeks were investigated: birch Creek; Jim Crow Creek; East Moorabool Creek. Birch Creek, located in the north central region of Victoria, is a major tributary of the northward flowing Tullaroop Creek system in the upper catchment of the Loddon River. The riparian vegetation includes native *Eucalyptus* spp., *Acacia* spp., *Callistemon* spp., *Leptospermum* spp. and exotic *Salix* spp. (willows), with intermittent reed dominant stretches. The dominant land uses adjacent to the creek are grazing and cropping. Jim Crow Creek is also a tributary of the Loddon River, containing native vegetation, exotic willows and intermittent reed beds. It largely flows through public land. The East Moorabool is a branch of the Moorabool River, which originates in the Great Dividing Range in Central Victoria. It flows through native forest and agricultural areas and has stretches dominated by willows and *Phragmites*.

Sampling

Six sites (each a 100 m reach) were sampled from each of the three creeks, two sites per creek. Each site had stretches of willows, *Leptospermum/Callistemon*, *P. australis* and bare banks. Six random samples were collected from each of these four 'habitat types' during each season of 2004: early February, May, August and October. Sampling occurred within three consecutive days to counteract the effect of within season variation. A total of 576 samples (6 sites x 4 habitats x 6 samples x 4 seasons) were collected. *Leptospermum* and *Callistemon* were considered as defining one habitat representing shrubs as both were distributed commonly along banks at most sites. The channel features and bank characteristics of sampling sites are given in Table 1.

Samples were collected using a 20 cm x 20 cm horizontal metal frame attached to a sampler with a 250 µm mesh net (Surber sampler). The area inside the sample frame was excavated to a 5 cm depth and the whole sample, together with the portion retained in the net as a result of site disturbance, was collected and sealed in polythene bags. Fringing willow roots, which extended from the bank, were sampled after cutting the root fraction inside the metal frame of the sampler. *Leptospermum/Callistemon* roots were not as extensive as willow roots, and were more lignified and compactly structured. Sampling of *Leptospermum/Callistemon* roots followed the same collection technique. *Phragmites* was sampled after cutting the above ground portion of the plant and collecting the ground fraction within the sample frame. Any macroinvertebrates attached to stems were washed off and included in the sample. All samples were transported to the laboratory for sorting. Dissolved oxygen, pH, conductivity and temperature were measured *in situ* immediately prior to sampling using TPS field probes (TPS, MC 81, Brisbane, Australia). Flow and depth also were recorded. In the laboratory, samples were sieved (minimum sieve size 250 µm) and macroinvertebrates separated and preserved in 70% alcohol. Macroinvertebrates were identified to species where possible (Pinder and Brinkhurst 1994; Cranston 1996; Dean and Suter 1996; Smith 1996; CSIRO 1999; Gooderham and Tsyrlin 2002). Information from a number of sources was used to partition the invertebrate fauna into five major feeding categories,

viz shredders, collectors, predators, grazers and filter feeders (Merritt *et al.* 1984; Hauer and Lamberti 1996; Gooderham and Tsyrlin 2002). The live root fraction was removed from the sample and the remainder of the sample was divided into coarse particulate organic matter (>1 mm) (CPOM) and fine particulate organic matter (1 mm–250 µm) (FPOM), air dried for one day and oven dried at 105°C until constant weight was attained. After recording the dry weight, each fraction was ashed at 550°C for six hours and ash free dry weight (AFDW) determined.

Analysis

Two-way ANOVA was used to analyse data. The factors considered in the model were season and habitat. During the study, 92 macroinvertebrate taxa were recorded. Univariate tests were conducted using the general linear models procedure in the SPSS statistical package. Data were log transformed before analysis to maintain homogeneity of variance. Posterior pair-wise comparisons (Tukey's post hoc test) were conducted to estimate differences among groups in selected factors identified as significant in the ANOVA.

Results

Physical and chemical parameters associated with sampling sites

Habitat scale variations of temperature, pH, conductivity and dissolved oxygen were not significant; however, these parameters varied significantly between streams (Table 2) and seasons. In all sites (Fig. 1), maximum temperatures were recorded during summer and minimum values were recorded during winter. Conductivity also followed the same trend, with higher values during summer and lower values during winter and spring. Dissolved oxygen was mostly lower during summer and autumn and increased during winter and spring. Stream flow was higher during winter and spring in Birch Creek and Jim Crow Creek. Moorabool sites remained stagnant throughout the experimental period except for a slight increase in flow during spring. In *Phragmites* habitats, lower local flow was recorded in many sites during high flow seasons, and it was higher in bare banks. There was a significant ($p < 0.05$) increase in CPOM content in *Phragmites* habitats in most sites compared to other habitats during winter and spring, and in willow habitats during au-

Table 1. Channel features and bank vegetation characteristics of study sites (W = willows; P = *Phragmites*; L = *Leptospermum/Callistemon*; B = bare banks).

Site	Length (m)	Mean Width (m)	Mean Depth (cm)	dominant substrate at bare bank	% bank cover				
					W	P	L	B	Other
1	120	6	31	Gravel/cobble	20	15	20	20	25
2	100	3	25	Silt/gravel/clay/scattered grass	15	25	15	30	15
3	120	5	29	Gravel/cobble/scattered grass	20	10	20	30	20
4	100	5	27	Sand/gravel/cobble	20	20	18	17	35
5	100	6	29	Silt/clay/gravel/coarse woody debris and scattered grass	15	18	23	15	29
6	100	7	34	Silt/clay/gravel/abundant plant debris/many grass	18	17	30	15	20

Table 2. Physical and chemical parameters recorded in streams during the experimental period (values were recorded from study sites within streams).

Parameter	Range		
	Birch Creek	Jim Crow Creek	Moorabool
Temperature (°C)	9.3-20.4	8.1-24.4	8.4-18.9
Conductivity (µS/cm)	179-1763	38-559	378-545
pH	7.7-7.9	7.8-8.8	7.6-8.1
Dissolved oxygen (mg/L)	5.3-12.8	5.9-14.2	4.3-12.4
Average flow (m/sec)	0-2.0	0-2.0	0-0.5

tumn. In *Leptospermum* habitats, higher CPOM was recorded during summer in most sites compared to winter and spring. Higher FPOM was recorded in *Phragmites* habitats compared to other habitats in many sites. In willow and *Leptospermum* habitats, more stable levels of FPOM were recorded in many sites (Fig. 2).

Macroinvertebrate functional feeding groups associated with habitats

Shredders

There was a significant effect ($p < 0.05$) of habitat on shredder abundance (Table 3). In all seasons, shredder abundance was highest in willow habitats (Fig. 3). This increase was more prominent during spring. In the other three habitats, more or less similar numbers of shredders were observed. In all habitats, Hyalidae and Paramelitidae were the dominant families, contributing to more than 90% of the shredder abundance.

Predators

There was a significant effect of habitat ($p < 0.05$) on predator abundance (Table 3). In all seasons, except summer, predator abundance was highest in *Phragmites* habitats. During summer, *Leptospermum* and bare banks had higher predator abundance. Major taxa that contributed most to the predator abundance in *Phragmites* habitats were Tanypodinae (42.69%), Coenagrionidae (25.44%) and *Ecnomus* sp. (6.39%). In bare banks, Corixidae (adult and nymph) (31.73%), *Necteresoma* sp. (20.53%) and Tanypodinae (18.66%) were the major predators.

Grazers

Habitat also showed a significant association ($p < 0.05$) with the abundance of grazers. Grazer abundance was also higher in *Phragmites* habitats. This was more prominent during autumn, winter and spring seasons. However, in willow habitats, the highest number of grazers was re-

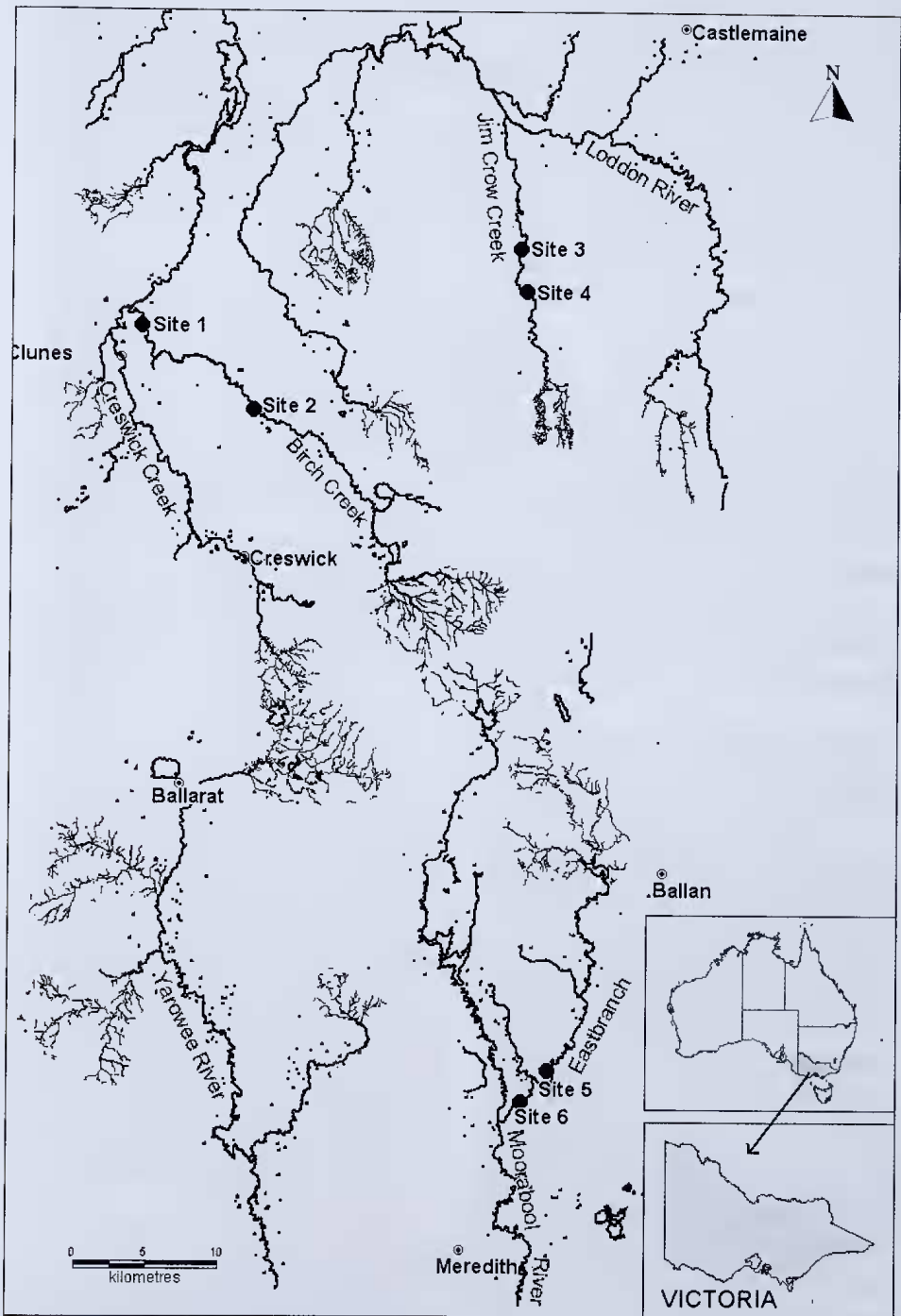
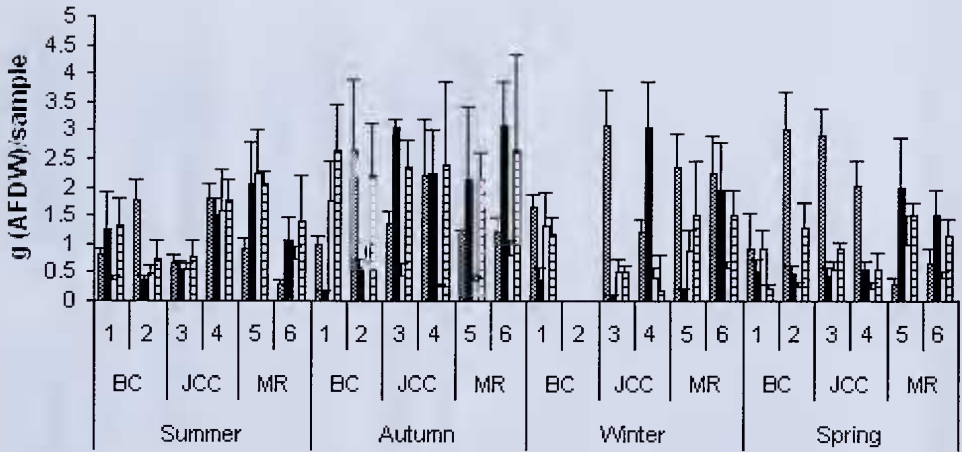


Fig.1. Sampling sites.

CPOM



FPOM

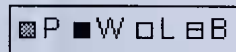
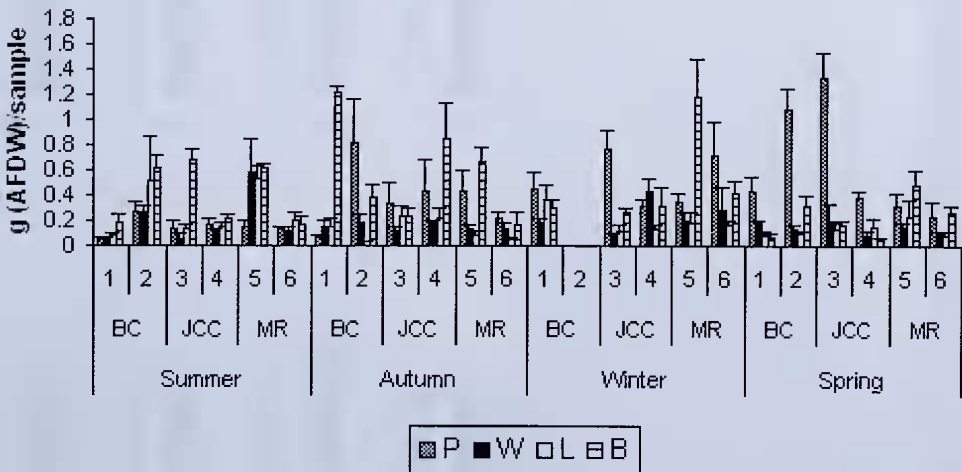


Fig.2. Mean \pm SE of coarse particulate organic matter (CPOM) and fine particulate organic matter (FPOM) in habitats during different seasons. P = *Phragmites*; W = willow; L = *Leptospermum/Callistemon*; B = bare bank. BC=Birch Creek; JCC= Jum Crow Creek; MR= Moorabool River.

corded during autumn. Major taxa contributing to total grazer abundance in willow habitats were *Potamopyrgus antipodarum* (45.22%), *Glyptophysa* sp. (15.08%), Orthoclaadiinae (14.32%) and *Physa acuta* (12.54%). During summer and autumn, *Potamopyrgus antipodarum* and *Physa*

acuta contributed 53% and 14.5% respectively to the total grazer abundance in willow habitats. In *Phragmites* habitats major taxa, which contributed to total grazer abundance, were Hydroptilidae (22.09%), *Physa acuta* (18.14%) and *Glyptophysa* sp. (17.06%).

Table 3. Results of two-way ANOVA on functional feeding groups with habitat and seasonal associations

source	df	shredders			collectors			predators			grazers			filter feeders		
		MS	F	P	MS	F	P	MS	F	P	MS	F	P	MS	F	P
season	3	0.693	4.65	0.003	1.594	6.460	0.000	0.756	4.814	0.003	1.95	7.850	0.000	5.779E-02	0.223	0.880
habitat	3	1.751	11.77	0.00	0.552	2.236	0.083	0.761	4.841	0.003	1.77	7.127	0.000	1.233	4.770	0.003
season*habitat	9	0.195	1.31	0.229	0.689	2.793	0.003	0.257	1.635	0.103	0.43	1.749	0.070	0.246	0.951	0.481
error	536	0.149			0.247									0.259		
total	552															

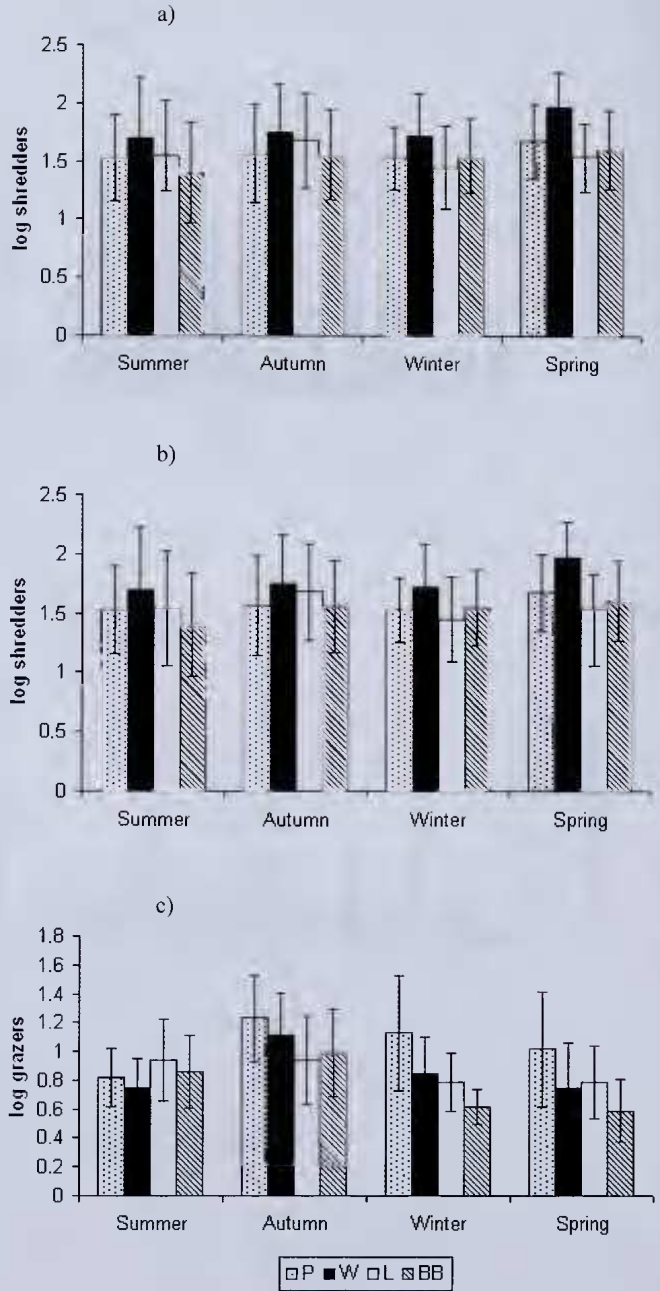


Fig. 3. Mean \pm SE of (a) shredders, (b) predators, (c) grazers associated with habitats during different seasons. P = *Phragmites*; W = willow; L = *Leptospermum/Callistemon*; BB = bare bank.

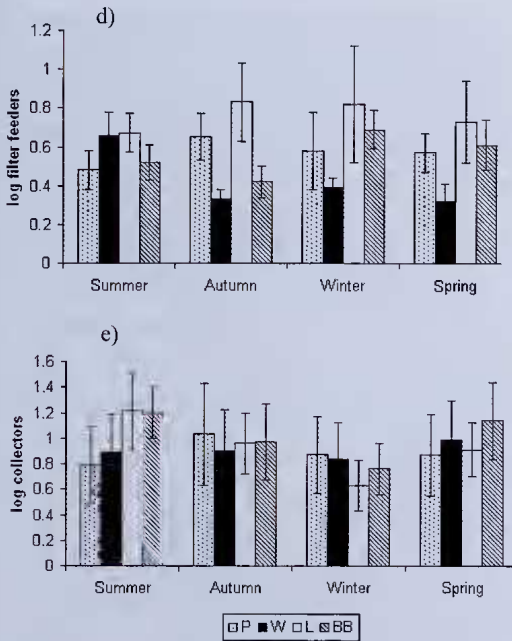


Fig. 3. Mean \pm SE of (d) filter feeders (e) collectors associated with habitats during different seasons. P = *Phragmites*; W = willow; L = *Leptospermum/Callistemon*; BB = bare bank.

Filter feeders

There was a significant association ($p < 0.05$) between habitat and the abundance of filter feeders (Table 3). Notable increase in filter feeders was observed in *Leptospermum/Callistemon* habitats during autumn, winter and spring. Bare banks and *Phragmites* habitats also showed marked increases in filter feeders. In *Phragmites* habitat, *Pisidium* sp. (55.53%) and *Sphaerium* sp. (38.54%) were the major filter feeder taxa. *Simulium* sp. (45.96%), *Sphaerium* sp. (15.38%) and *Pisidium* sp. (12.82%) contributed most to filter feeder abundance; however, Simuliidae were more abundant during winter and spring, contributing 91.93% and 75.00% respectively with lowest values during autumn (4.65%). *Sphaerium* sp. and *Pisidium* sp. percentages were highest during summer (41.51% and 35.85% respectively) in willow habitat. In *Leptospermum/Callistemon* and bare bank habitats, *Sphaerium* sp. and *Pisidium* sp. were the most abundant filter feeding taxa. *Simulium* sp. also was abundant in bare banks during winter and spring.

Collectors

There was no significant association between habitats and the abundance of collectors (Table 3). Major families contributing to collector abundance in *Phragmites* habitat were *Wundacaenis* sp. (45.83%), Chironominae (17.88%) and *Tasmanocoenis* sp. (11.91%). Major families contributing to collector abundance in willow habitats were Chironominae (24.71%), *Wundacaenis* sp. (23.31%), *Tasmanocoenis* sp. (14.11%) and Elmidae larvae (11.84%). The highest percentage of Chironomidae was recorded in willow habitat during winter (56.29%). In *Leptospermum/Callistemon* habitats, *Wundacaenis* sp., Chironominae, Elmidae larvae and *Tasmanocoenis* sp. contributed more than 75% of the total collector abundance. In bare bank habitats, *Wundacaenis* sp., Chironominae, *Tasmanocoenis* sp. and Tubificidae contributed more than 80% of the total collector abundance. In *Phragmites* habitats, there was a seasonal increase of collectors during winter and spring in many sites compared to summer and autumn. A similar trend was observed in bare bank habitats during spring.

Discussion

A positive correlation between shredders and CPOM content has been reported by many authors (Dudgeon, 1989; Read *et al.*, 1994). As suggested by Vannote *et al.* (1980), shredder abundance is closely related to the autumn leaf fall pattern of forested streams in the Northern Hemisphere. Cummins *et al.* (1989) suggested that shredders are closely linked to the timing of litter inputs; however, contrary to this, Bunn (1986) found the abundance of shredders was not synchronised with peak summer leaf fall. Further, Barmuta (1988) found low correlations between surface organic matter and density of shredders in South Australian streams, and Towns (1985) noted that few taxa were using leaf litter in the pools of intermittent streams; however, the present study showed no clear relationship between organic matter content and shredder abundance in these habitats. Despite the higher leaf litter input during winter and spring, no significant increase in the abundance of shredders was observed in *Phragmites* habitat during those seasons. Similarly, in willow habitats, higher organic matter content was observed during autumn; however, no increase in shredder abundance was observed during autumn. Many factors affect the leaf organic

matter utilisation by shredders. Leaf toughness has been implicated as a deterrent to consumption of eucalypts by terrestrial herbivores (Ohmart *et al.* 1987). Hanlon (1981) noted that disruption of leaf surface by abrasion increased both the preference and growth of the hydrobiid snail *Potamopyrgus jenkinsi* (Yeates and Barmuta 1999). Some studies have shown that most invertebrates find willow detritus becomes more attractive when it has been conditioned for some time (Collier and Winterbourn 1986; Lester *et al.* 1994). This has been related to increased microbial conditioning (Collier and Winterbourn 1986) or the removal of secondary compounds that affect invertebrate feeding (Lester *et al.* 1994). There is also evidence to suggest that water quality has a profound influence over the microbial decomposition of leaves, thereby reducing microbial activity and reducing consumption by shredders (Bärlocher 1990; Sridhar and Bärlocher 1993). These factors may have contributed to the poor correlation between CPOM and shredder abundance associated with the habitats. It has been seen that there is an increase in shredders in willow habitats during spring. None of the other habitats showed such an effect. It is possible that habitat architecture plays an important role in habitat selection by particular groups of shredders. It is possible that refuge sites provided by structurally complex willow root mats favour their abundance in this habitat to escape from adverse physical forces such as strong currents. Possibly, decomposing willow root mats provide favourable habitats for shredders in these streams. This emphasises the importance of willow root habitats as refuges for certain groups of macroinvertebrates.

As previously predicted, predator abundance recorded in *Phragmites* habitat was higher compared to other habitats during all seasons except summer. Predator abundance recorded in bare bank habitats was also higher during summer. Taxa responsible for predator abundance in each habitat type were different. It is evident that predators in these two habitats during different seasons may be related to the emergence pattern of the taxa associated with these habitats. Some effects of habitats on predators are due to the differences in depth of each habitat. Coleoptera and Hemiptera were more abundant in bare banks and associated with shallow habitats, whereas in *Phragmites* habitat one of

the common groups of predators, Odonata, was found in relatively deeper depths. This suggests that habitat depth acts as a separate niche space, which may reduce the degree of competitive interactions for food in the predator guild (Schmid and Schmid-Araya 1997).

Higher water temperature and light intensity during summer were found to stimulate primary production and lead to an increase in the abundance of grazers (Minshall 1978; Vannote *et al.* 1980). Even though grazers were expected to be more abundant in bare banks, grazer abundance was higher in *Phragmites* habitats compared to other habitats in all seasons except summer. As expected, grazer abundance in willow habitat was lower during summer. However, a relative increase in grazer abundance could be observed during autumn. It is possible that increased shade under the willow due to full canopy cover during summer hinders the light penetration to the channel, reducing primary production and hence causing a reduction in grazers. Not only primary production but other factors, such as bio-film attached to leaf matter and roots, contribute to the abundance of grazers (Lock 1981). This must be one of the reasons for the increased number of grazers recorded in willow habitats during autumn and in *Phragmites* habitats during autumn, winter and spring. The major group contributing to grazers in willow habitats was *Potamopyrgus antipodarum*. *Physa acuta*, an organic pollution tolerant taxon also contributed to the abundance of grazers in willow habitats. *Physa acuta* also contributed to grazers in *Phragmites* habitats but were most abundant during winter and spring, possibly due to increased organic matter content during these seasons. In *Phragmites* habitats, Hydroptilidae were the dominant grazers during summer, possibly because of low flow and increased attachment sites available to this taxon.

Filter feeders feed on suspended particulate matter. Flow increases the suspended particulate matter in streams and facilitates filter feeder abundance (Parker and Voshell 1983). In the present study, filter feeders were more abundant in *Phragmites*, *Leptospermum/Callistemon* and bare bank habitats; however, the reason for the increase of filter feeders in *Leptospermum/Callistemon* and bare banks habitats was not clear.

Collectors are considered to be the indicators of FPOM content in streams. They were found to be dominant in headwater streams by Cum-

mins (1974) and Hawkins and Sedell (1981). Summer low flows facilitate the settling of FPOM and have been found to increase collector abundance (Bunn 1986). Huryn and Wallace (1987) suggested that collectors and shredders are more common in low velocity high retention pools. Read and Barmuta (1999) surveyed nine rivers in south-eastern Tasmania to identify the differences between reaches of river lined with willows and those with native vegetation in community structure of benthic invertebrates and the resources these plants use. This study revealed that willow roots enhance deposit feeding collectors during summer due to fine sediment in these habitats due to summer low flow. In the present study, collector abundance showed no significant variation among habitats. Flow exerts a positive effect on collector abundance because they depend on downstream transport of material. It can be assumed that invertebrate functional feeding groups associated with middle channel habitats such as pools and riffles are significantly affected by flow frequencies at site scale. In the present study, sampled habitats were in a depositional littoral zone where the flow effect is relatively low. This may have also contributed to the little differences observed in collector abundance among habitats in the present study. Many authors have suggested that *Phragmites* habitats are favourable for macroinvertebrates due to reduced flow and the settling of particulate matter and sediments (Weinstein and Balletto 1999; Rooth and Stevenson 2000); however, no such association between *Phragmites* habitats and collectors was observed. In all habitats, Ephemeroptera and Chironominae were the major groups contributing to total abundance of collectors. In willow habitats, Elmidae, and in bare banks, the Tubificidae, also contributed significantly to the total abundance of collectors. A significant increase in Chironomidae percentage also was observed in willow habitats during winter; however, the reason for this increase was not clear. It is possible that some of the accumulated leaves, after conditioning in those habitats, facilitate Chironomidae abundance in those seasons under willows. In bare banks Tubificidae percentage also increased during winter and spring compared to other seasons. It is possible that redistribution of particulate organic matter due to onset of flow may have facilitated this increase.

In summary, this study showed that the different vegetation communities investigated have

significant influence over the functional organisation of macroinvertebrates in these streams. There were some trends, which could be observed in this study, which facilitated the better understanding of functional feeding group variation among habitats. In all habitats, shredders were the most abundant group recorded. A major distinction in functional feeding groups was observed in willow and *Phragmites* habitats. In willow habitats, shredders were more abundant. In *Phragmites* habitats, the major difference was predator and grazer abundance. *Leptospermum/Callistemon* and bare banks showed similarities in terms of filter feeder abundance. Collectors showed no clear habitat specific distribution. This suggests that vegetation changes from willow removal can change macroinvertebrate functional organisation, as well as bring about change in the material cycle and energy flow within these streams.

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